



# **Within-Stand Retention Guidance**

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## 1. INTRODUCTION

**Purpose.** The purpose of the Within-Stand Retention Guidance (Guidance) is three-fold. First, this document provides guidance to Department of Natural Resources (DNR) resource managers, in the area of stand level elements of retention. That is, the information is to guide the prescription process for retention of snags and live trees in stands scheduled for harvest treatments. Second, this Guidance is to provide a scientific, ecological basis for the retention prescriptions. An attempt has been made to review the current literature on the subject and synthesize the research into practical field guidance. Third, this Guidance highlights certain important ecological features about each major forest cover type including sensitive plants, animals and other features that are likely to occur within stands of these types.

**Organization.** The Guidance provides a general discussion of the ecological context of stand-level retention, including general guidance on features commonly considered for retention. This is followed by specific details for determining how much, what and where trees and snags should be retained. The last part of the Guidance consists of a series of sections describing each major cover type, associated sensitive features and other retention issues that should be considered when working in stands of these types.

**The Larger Context.** A separate project is underway to write silvicultural guidance and management guidance for the major cover types. The silvicultural guidance focuses on the biological characteristics of each cover type, while the management guidance will recommend management methods to achieve a range of desired outcomes within each cover type. This Guidance was originally conceived to be part of the management guidance, but time constraints and the requirement to complete within-stand retention materials to resolve a forest certification corrective action dictated that the projects be separated. As a result, this document is the first of the guidance documents to be completed. When the other documents are finished, this Guidance will be incorporated into the final package.

**Authorship.** This Guidance is the collaborative work of a large number of people from the Forest, Mineral and Fire Management (FMFM) and Wildlife divisions of Michigan Department of Natural Resources (DNR). Contributing authors include wildlife ecologists, timber management specialists, inventory and planning specialists, wildlife planners, and Michigan State University faculty. Numerous technical experts from other agencies and universities contributed to this body of information as well. Editing was done primarily by a core team consisting of Ron Murray (DNR-FMFM), Mike Walters (MSU), Keith Kintigh (DNR-WLD) and Jim Ferris (DNR-FMFM). Management teams from Forest Management, Fish and Wildlife divisions contributed many helpful comments and approved the final version.

## **2. PLANNING FRAMEWORK**

The Michigan Department of Natural Resources (DNR) attempts to balance social, economic, and ecological values and impacts in managing State Forest lands. This is accomplished with a vegetation community management system that integrates landscape-scale and stand-scale approaches with the aid of several tools including: eco-regional plans, habitat-species models (e.g., MI WILD (Doepker et. al., 2001)), stream classification systems, Wildlife Action Plans, Michigan GAP Analysis, ecological classification systems (e.g., habitat types, Burger and Kotar 2003) and current and historical cover type distributions. Social and economic values are also considered when determining management direction. Landscape-scale planning activities consider how much land is suitable for a particular vegetation community type and where cover type (community) management should occur. Based on site suitability, several different communities may be viable choices at a given site; however, some might have higher priority for perpetuation or establishment given their ecological/biological, social, or economic values. Stand management decisions are made within the context of landscape-scale plans in a multi-disciplinary compartment review process. These decisions determine how much, where, when and how a cover type will be managed. Density, age, composition and structural attributes of the stand are also determined through this same process. Stand-scale decisions are critical because smaller stand-level units comprise communities. In turn, communities aggregated geographically comprise landscapes, and as such, their collective characteristics and distributions affect a multitude of ecological/biological, social, and economic values over large geographic areas.

Tree retention information is intended to address the important smaller spatial scale component of the landscape/eco-regional planning process. It is intended to be applied at the stand scale following landscape level planning and multi-disciplinary harvest decisions using managerial discretion and sound professional judgment. In other words, after the “how much, where, when and how a cover type (community) will be managed” decisions have been made, this guidance directs the retention of live and dead trees. It is not intended to describe or guide decisions at the landscape level. The information should be viewed as guidance to help land managers determine which trees should be retained during harvest treatments, particularly harvests with regeneration objectives. Managers should generally follow this Guidance, but must retain the option to deviate in specific instances when the direction does not contribute to overall landscape management goals.

## **3. ECOLOGICAL CONTEXT**

The purpose of this section is to establish the ecological rationale and framework for retention prescriptions. Information is focused on characteristics of retention that are considered important for ecological and biological functionality, including wildlife and biological diversity. Retention has other ecological values (e.g., carbon and nutrient retention) and social and economic impacts, but most current retention literature focuses on wildlife and biodiversity issues. This Guidance may change in the future as new biological, ecological, social and economic information becomes available.

Wildlife populations are impacted by stand structure and composition and the size and spatial arrangement of stands across the landscape. In general, wildlife abundance and diversity have been shown to correlate with structural and tree diversity within a stand (Menard et. al. 1982). For example, black-throated green warblers (BTGW) use mature

northern hardwood stands containing about 15%-20% mature conifer component. The conifer component must be present for the BTGW to settle in the stand and to be used as a breeding site. Another example is black-throated blue warblers (BTBW) which depend on mature forest conditions with well-developed shrub/sapling layers (Kearns et. al. 2006). However, it would be overly simplistic to prescribe maximum structural and compositional diversity for all stands. Kirtland's Warbler (KW), for example, is dependent on a horizontal structure of 200+ acre stands of young age class, dense jack pine trees, interspersed with small openings in compositionally simple jack pine forests (Probst and Weinrich 1993). Habitat use and selection data is not available for all wildlife species. Thus, it is assumed that the habitat requirements for the greatest number of native wildlife species are provided by maintaining a broad representation of forest composition, structure, acreages and age classes across the landscape (Hunter 1990). This coarse filter approach is difficult to refine to a more specific distribution of forest conditions required by wildlife because of the complexity of vegetation-wildlife relationships and the great number of unknown species-habitat requirements. Appreciation of this problem has led to the emergence of the paradigm that harvesting patterns mimicking natural disturbance patterns may provide habitat for the greatest number of species (Attiwill 1994). Such an approach is based on the assumption that species have adapted and evolved with the habitat conditions resulting from natural disturbances at the landscape level.

Green and dead tree retention and targeting specific tree and patch characteristics for retention is a means for increasing structural and compositional diversity at the stand scale. Management specifications for retention should vary from cover type to cover type (see specific suggestions for cover types in later sections), according to established and emerging understanding of silviculture and disturbance dynamics, but also from site to site within cover types for the same reasons. For example, within a cover type, in addition to stands where vegetation diversity is increased via specific retention prescriptions, some stands could be targeted for low structural and compositional diversity and little retention, as these stands represent part of the distribution of stands on the landscape that natural disturbance would create, i.e., KW habitat. Stand managers should consider historic conditions and consult larger scale plans before harvest and retention planning. Pre-settlement conditions are often referenced as a bench mark representing forest landscape conditions before major changes resulting from harvesting, fire and fire exclusion during the last 150 years. Pre-settlement conditions are not intended to describe desired future conditions, but rather as a tool to inform modern management decisions. Important retention characteristics should focus on function and process of within stand vegetation characteristics, as expressed through wildlife and biodiversity concerns. These include tree species diversity, mast trees, structural diversity, cavity trees, micro-habitats, and standing and downed dead wood. Following are descriptions of the general features of these characteristics and some examples of retention standards for specific cover types where these conditions exist.

#### **4. TARGETED RETENTION CHARACTERISTICS**

Retention areas and components are expected to be generally representative of the stand composition prior to harvesting. In addition, retention provides opportunities to enhance several characteristics considered important for a broad range of ecological values. In this section, some of these characteristics are described with an emphasis on their value to wildlife, and general guidance is provided on managing for these characteristics.

## A. Tree Species Diversity

The number of wildlife species using a stand is thought to be positively correlated with stand composition and structural diversity, including trees in the overstory (Ontario Ministry of Natural Resources, 1998). In stands where the maintenance or enhancement of tree diversity is a goal, managers should encourage a mix of species that are associated with site conditions, either presently, or historically. Maintenance or enhancement of tree diversity is a common stand-level goal. Where this is the case, managers should encourage a mix of species that are associated with site conditions, currently or were historically present and can be manipulated to meet stand (i.e. successional) and landscape goals. General resources that can aid in this assessment include Burger and Kotar (2003) for species and successional tendency associations with site, and pre-settlement forest cover maps (<http://web4.msue.msu.edu/mnfi/data/veg1800.cfm>). Management objectives for each stand should address targets for species diversity in both: a) the residual overstory, and b) the future overstory and in the case of uneven-aged management, the understory composition and structure. Often it will be appropriate to promote tree species diversity by favoring under-represented species for retention. Under-represented species are defined as those that are ecologically appropriate for the site and/or have ecological values that are desirable to enhance. Examples include: 1) mast producing species (see below), 2) long-lived species in short rotation stands (e.g. white pine in aspen stands), and 3) conifers in deciduous stands and vice versa. Conifers in hardwood stands such as white pine, hemlock and white spruce provide considerable value for wildlife. Conifer inclusions in these and other stand types serve as thermal cover and habitat for mammals including deer, pine marten, fisher, and black bear. Large, “super-canopy” trees serve as nesting habitat for bald eagles, osprey, and several other raptors.

## B. Mast Trees

In Michigan, approximately 15% (55 species) of all terrestrial vertebrate wildlife species are associated with mast (MIWildHab (Doepker et. al., 2001)). These species rely on mast during peak production periods in late summer and early fall. High levels of fat, protein and carbohydrates in mast contribute to energy stores critical for migration, hibernation, and/or survival of young (Schnurr et. al. 2002). Mast species, in descending order of importance, are: hickory, oak, American beech, black cherry, basswood, and ironwood (OMNR 1998). Preferred mast trees are at least 10 inches dbh, with large, vigorous crowns. When selecting beech trees for retention, evidence of bear claw marks on the bark may indicate a consistent mast producer. In addition to trees, there are many mast producing shrubs, including *Viburnum*, *Amelanchier*, hazelnut, and cherries. Harvest impacts on these shrubs should be minimized where possible.

## C. Stand Structure

Forest structure can be described as the distribution of a collection of structural attributes which include, among others, canopy cover, tree spacing, species, height, diameter, understory and deadwood (McElhinny et. al. 2005). The number of wildlife species using a stand or landscape may be influenced by their respective structural complexities, but few studies have examined these relationships (e.g. Tanabe et. al. 2001). Structure, and its complexity, i.e., diversity, can be divided into vertical and horizontal components.

*Vertical Diversity.* At its simplest, vertical structural diversity can be defined as the number of vertical strata (i.e. layers) in the stand. Examples of important and sometimes under-represented vertical structural features include downed wood (see below), understory shrub, sapling layers, sub-canopy, mid-canopy and large and/or super-canopy trees. The density of understory shrub and sapling layers are dependent on many factors, including species composition (Oliver and Larson 1996), silvicultural management practices, canopy openness, site fertility, and deer browse (Randall and Walters 2004). Maintaining or promoting these strata may be enhanced by increasing the size of openings in partial harvests, and protecting these layers from harvest damage. Large trees can be increased by permanent designation as reserve trees or groups of trees and by extending rotation age. The development of large trees can be accelerated by canopy release thinning around target trees (Singer and Lorimer 1997). Super-canopy trees are large diameter trees that emerge above the main canopy of the stand. Super-canopy trees can be of any species; however, red pine, white pine, and white spruce are more likely than other species to be super-canopy trees because of the greater height they achieve compared to their associates, and their longevity. Specific recommendations include: 1) retain super-canopy trees, particularly white pines, adjacent to nesting areas and within approximately 1,300 feet of lakes or rivers to provide perch, roost and future nest sites for eagle and osprey (Rogers and Lindquist, 1992) and; 2) retain at least one super-canopy tree per 10 acres, where possible, to provide refuge trees and bedding sites for black bears. Retaining larger trees in stands can lead to the development of super-canopy trees where none currently exist.

*Horizontal Diversity.* Horizontal structural diversity is defined as variations in land surface cover at the stand or landscape scale. Similar to vertical structure, a broad range of horizontal structures may be important for wildlife diversity. Natural disturbances such as windstorms, fires, and insect infestations create openings of various sizes that, in turn, produce a broad range of horizontal structures. In areas where increasing stand-level horizontal structural diversity is desirable, it can be enhanced by: 1) including a broader range of opening sizes in stands primarily managed with the single tree selection system (e.g., establishing some group selection openings and small patch cuts in addition to single tree removals); 2) leaving some residual trees in clumps in stands receiving a regeneration cut in the shelterwood system or in seed tree system harvests; and 3) leaving some scattered patches of residual overstory in removal cuts and clearcuts.

#### **D. Cavity Trees, Standing Dead, and Downed Wood**

Compared to unharvested forests, forests with a history of logging generally have lower densities of live cavity trees (Goodburn and Lorimer 1998), snags (Newbery 2006) and downed woody debris (Goodburn and Lorimer, 1998, Angers et. al. 2005). The presence of these characteristics is important for several species (Haartman 1957, Thomas et. al. 1976, Thomas et. al. 1979a, Dickson et. al. 1983). However, specific relationships between the density of these features and the presence/absence of dependent species are generally unknown. Coarse woody debris in the form of down trees has a positive and significant effect on habitat availability in streams and lakes, and helps provide increased productive capacity for fish and aquatic invertebrates (Naiman and Latterell, 2005). However, the presence of downed trees and woody debris in water also has a dramatic effect on riparian habitat quality (Gregory et. al. 2003). Management activities in forested systems can have a negative effect on the supply of habitat for cavity users because: a) dead trees may be felled to comply with safety regulations, and b) declining trees may be

preferentially removed to ease harvesting activities and meet timber production objectives of accelerating growth. The Ontario Ministry of Natural Resources (OMNR, 2001, 2004) recommends the following for densities of living cavity trees and snags for wildlife: retain at least 3 living cavity trees per acre, and up to 10 per acre as a combination of living cavity trees and dead and dying snags. Leaving a range of diameter classes (generally, larger is better) and a variety of tree species is preferable.

Specific guidance for downed woody debris (DWD) is lacking. In managed stands, where the amount of DWD is thought to be significantly lower than in unmanaged stands, several strategies could be used to increase DWD. They include: 1) encourage operators to leave unmerchantable portions of tree boles at harvest sites to provide large diameter DWD; 2) leave the tops of harvested trees distributed through the stand and not windrowed or piled at roadsides; 3) if DWD is lacking, consider girdling or felling and leaving unmerchantable stems. In addition, the DWD of hemlock and cedar, and perhaps other conifers, persists 2 to 3 times longer than hardwood DWD (Mattson et. al. 1987, Marx 2006). Although the felling or girdling of conifers may be undesirable, their retention as live trees may be desirable for many reasons, including their eventual death and contribution to DWD; 4) consider reducing or eliminating firewood permits in areas with low DWD. Firewood collecting reduces both the amount of DWD and possibly the number of snags; 5) when considering prescribed burns, conduct them pre-harvest or burn when the moisture content of DWD is high. This will help to preserve DWD integrity; 6) in stands where heavy mortality has occurred, design salvage cuts to leave some dead standing and downed wood. This is most important in large acreage salvage cuts.

#### **E. Additional Considerations for Retention**

*Windfirmness.* In addition, or at times, in opposition to the desired elements for live tree retention described above, windfirm trees or clumps of trees should be preferred for retention. Studies following the fate of retained trees in clearcuts found that a high percentage of retained trees uproot or snap in the first few years following harvest (Hautala et. al. 2004). In addition, logging damage to trees often introduces decay organisms that can cause trees to die from stem snap (Bebber et. al. 2005). Trees with cavities are desired for retention, but are particularly susceptible to snapping. These trees may be partially protected from snapping by reserving them in clumps of other trees. In general, super-canopy trees are windfirm because their crowns have been exposed to high winds for a long time. Trees that have particularly poor windfirmness are those growing in areas with elevated water tables (since their roots are shallow) and those of co-dominant or lesser canopy positions that developed in high density even aged stands. These trees have not been exposed to high winds, and the high height to diameter ratios they developed under these crowded conditions make them more vulnerable to high winds (Scott and Mitchell 2005). For site and stand conditions with a high susceptibility for windthrow, consider higher stocking levels for post harvest retention. For example, retention of greater than 20% has been recommended in highly susceptible conditions (Scott and Mitchell 2005).

*Retention Dynamics.* Trees and tree patches retained after harvest are dynamic such that many of the targeted attributes contained in retention also change. For example, the number of live tree cavities could change over time, as some trees with cavities die and others develop cavities as they get older. In planning retention, care should be given to provide for target characteristics through at least the end of the next rotation (Stone et. al. 2002). For selection harvest systems, this planning may be

relatively simple given the short harvest return interval. However, in clearcut systems with long return intervals, planning will be more complex and could include the retention of trees or clumps of trees expected to develop target characteristics over time, in addition to those trees or patches that currently do. In addition, planning for longer rotation clearcuts could include locating trees with desirable wildlife characteristics in the middle of retention patches to increase protection from wind and/or exposure. Tying retention patches into other no harvest, or limited harvest areas, such as riparian zones, would further increase patch protection.

*Forest Health.* Some species that could be used for retention have health issues which must be carefully considered. For example, residual red pine can harbor *Diplodia* shoot tip blight which will infect red pine seedlings, and may stymie efforts to produce multi-storied red pine stand, if that is the goal. Several other species have insect/disease problems [e.g., beech (beech bark disease), oak (oak wilt), and ash (Emerald Ash Borer)] that could limit their use as retained green trees in some areas. Specific forest health information can be found in DNR Silvics Guides, Management Guides, guides for specific pests and other sources. These should be consulted before prescribing retention.

*Sensitive Areas.* Relatively rare and/or valuable habitats need protection. Some of these, such as oak barrens/savannas and dolomitic boulders, are treated in the cover types that they occur in (In “Cover Type Specific Considerations” below). On any cover type, hydric and riparian communities such as vernal pools, intermittent streams, and seeps should be treated as special features. Where these occur, Best Management Practices (BMP) Guidance (MDNR, 1994) should be followed. In addition, skid trails and landings should avoid seeps whenever possible, and tree tops should not be left in vernal pools, streams or wetlands. A tree length buffer should be maintained around vernal pools, springs and seeps. Greater than 70% canopy closure should be maintained when possible to provide shading and cool water temperatures, especially for vernal pools. Areas set aside to protect these features can be considered a portion of retention under the Guidance.

*General Wildlife Considerations.* Many wildlife species, especially those that are uncommon, should benefit from general habitat conditions created by favoring the retention elements described above. Although, some species may still need protection for critical site-specific habitats such as nest sites (e.g. northern goshawk and red-shouldered hawk). Providing for a sustainable supply of suitable habitat per management guidance for these and other species may be critical to maintaining their presence. For example, Bald Eagles may be nesting where super-canopy white pine occurs in northern hardwood stands. Where eagles are nesting, Bald Eagle Guidance, as outlined in the Bald Eagle Recovery Plan for the Northern States (USFWS 1983), must be followed.

Young, regenerating stands can provide food and cover for many wildlife species, including ruffed grouse, snowshoe hare, and Chestnut-sided Warbler. Habitat can be improved for these wildlife species, if residual trees are retained for singing/song perches, hunting and hawking trees, and slash and/or downed logs are retained after harvest. Downed logs retained on site should be at least 12 inches in diameter, 8 feet in length, and at a density of 1 per acre. An intensive management technique to assist rabbits and hares is to create slash piles every 50 to 100 feet.

Sites with a dominant lowbush blueberry ground layer can be important feeding locations for black bears, white footed deer mice and other soft mast foragers in good

fruit years. Blueberry can be successfully promoted through the use of fire and silvicultural practices that expose mineral soil. Ideally, fires should be light (as hot fires can destroy roots) and conducted every 2 to 3 years.

In landscapes lacking significant lowland conifer, upland conifers may serve as important winter thermal cover for wildlife species, including white-tailed deer. Managers should identify such landscapes and consider management impacts on total available thermal cover.

Nesting woodland raptors use mature, forked hardwoods to build heavy stick nests. Other raptors need mature conifers within hardwood stands for nesting. Eagle and osprey will use super-canopy white and red pine. Black bear also use large white pine. Black bear sows commonly leave their cubs at mature white pine trees, where available, while they forage nearby in non-pine forest communities. Mature white pines have thick, fissured bark that escaping cubs can easily climb; Super-canopy trees that are at least 20 inches dbh are preferred. Trees that have bite marks, claw marks and show signs of disturbance at the base are trees that sows may be using year after year (Rogers and Lindquist 1992). For some songbirds, conifer retention is important. DeGraff (1987) reported that the abundance and diversity of songbirds declines below 4 conifer trees per acre in northern hardwood stands. Based on this research, the Ontario Ministry of Natural Resources recommends maintaining or attaining  $\geq 4$  large ( $\geq 16$ " dbh) conifers per acre, with a preference for trees with high vigor and low risk (OMNR 1998).

*General Aquatic Resource Considerations.* In riparian areas, retention of living and dead trees is usually desirable because they provide shade, contribute organic matter to aquatic food webs, and are a source of large woody debris (Benke and Wallace 2003, Boyer et. al. 2003, Dolloff and Warren 2003). Retained trees should be within one tree length of the stream for recruitment of large woody debris in the stream. Highly branched species and super-canopy trees will provide the greatest habitat benefits. Species such as hemlock, white pine and cedar will generally last longer in aquatic habitats than other tree species. In addition, stand management activities in riparian areas should be consistent with the DNR's riparian BMPs.

## **5. RETENTION GUIDANCE**

The guidance below will be incorporated into the timber sale checklist and timber sale contract conditions. Implementation will be evaluated as part of the general forest management review process.

### **A. Preferred Trees**

Retain all snags that do not pose a safety risk. Retain live trees in various patch sizes, with preference to the following elements where they exist:

- Under-represented species.
- Conifer/deciduous diversity.
- Mast trees-at least 3 trees/acre  $> 10$ " dbh where feasible.
- Large/super-canopy trees, at least 1 per 10 acres.
- Live cavity trees ( $\geq 3$ /acre), live cavity tree plus snags (up to 10/acre)  $> 10$ " dbh where feasible).

## B. Amount to be Retained

All harvests, including regeneration harvests, will have retention, unless a sound reason for “no retention” is provided, documented in the compartment review comments, and coded appropriately in the inventory system. The amount of live tree retention, and its association with harvest system names, is described in Table 1. below. Note, in general, retention in even-aged harvest systems is area based, and retention in uneven-aged systems and intermediate thinnings is residual basal area based. “No Retention” harvest systems listed in Table 1. are for those special cases where no retention has been justified and approved in compartment review. See the DNR Inventory Manual for harvest system definitions.

**Table 1. Amount to be Retained by Silvicultural System**

Retention Amount	Silvicultural System
No Retention <sup>1</sup>	Clearcut, Patch or Strip Clearcut, Seed Tree, Shelterwood
3%-10% of the area (acreage) in retention	Clearcut with Reserves, Shelterwood with Reserves, Seed Tree with Reserves.
3%-10% of the residual basal area in retention	Single Tree Selection, Group Selection, Thinning*

\*Includes “Crown”, “Low”, and “Systematic” thinning treatments.

<sup>1</sup> ‘No retention’ is an option that may be prescribed, but must be justified and approved as with any prescription at compartment review.

## C. General Guidance

- 1) Stand-level decisions on retention should be site specific and recommended by the stand examiner and Wildlife biologist. Their decisions should comply with this Guidance and information specific to individual cover types in the sections that follow. In addition, the Fisheries biologist should be consulted in cases of harvest within stream corridors, where large woody debris can provide multiple habitat benefits.
- 2) All harvests with retention should be designated as such (e.g., clearcut with reserves), and, in cases where it is justified, harvests that do not meet retention Guidance should be coded accordingly (e.g., Clearcut).
- 3) A description of the prescription for retention must be contained in the inventory notes section of the harvest prescription. This should contain the following information for retention: how much, what it is, general rationale for selection, location/distribution of larger patches, and special/unique features, if any.
- 4) Areas that will have limited or no harvesting due to factors such as inoperability or protection of sensitive micro-habitat can contribute toward, but not fully satisfy, retention requirements.
- 5) Areas selected for retention can vary over the stand. For example, a cluster of super-canopy white pine may cover a 1 acre patch in a 40 acre stand; it may be desirable to set aside this entire area as a reserve. Other areas within the stand can be left with little or no retention to balance the area reserved, as long as the stand, as a whole, conforms to the retention Guidance.

## D. Rationale for Area-Based Guidance

The retention guidelines have been written as area-based rather than tree stem density-based guidance for the following reasons:

- 1) Tree size can vary tremendously and the ecological effects and values of live trees, snags and DWD increase with their size. For example, seed production (Krannitz and Duralia 2004), size and density of cavities (Kearney 2006), and vertebrate usage of DWD increase with tree age. Area retained is likely a less variable measure of retention value for wildlife than number of stems. Also, targets for number of trees per acre with desirable wildlife characteristics can be easily imbedded in area-based retention provisions (e.g., 10% aerial retention can include 2 mast seeding oaks per acre. See the example in Section 6. below).
- 2) Area based retention guidelines should result in a greater tendency for inventory personnel to preserve patches than tree number based systems, which is desirable.

## 6. HOW TO ACHIEVE RETENTION OBJECTIVES

### A. Where the Retention Goal is a Percent of the Stand Area.

Retention goals can be met using scattered individual trees, patches and/or clumps of trees. For stands greater than 10 acres, patches are recommended (Flatebo et. al., 1999), but scattered trees can contribute to retention goals. Use Table 2. below to estimate trees per acre and spacing for various retention levels. Table 2. is based on crown area measurements in northern hardwood stands (Godman and Tubbs, 1973). Since only northern hardwood species were measured in this study, further crown measurements are needed to refine these tables. Until this information is available, use the following substitutions:

- Aspen or oak, use northern hardwood column.
- Spruce, fir, white pine, jack pine & red pine, use hemlock/other conifers, column.

**Table 2. Tree Crown Area**

DBH (in.)	Northern hardwood (sq. ft.)	Basswood (sq. ft.)	Hemlock/conifer (sq. ft.)
10	279	153	107
15	536	312	241
18	728	427	346
20	881	518	427
24	1207	712	612
26*	1,306	773	662
30*	1,571	933	806

\*These diameters are not included in the original table.  
Values were extrapolated from the published data.

Note: The crown areas above are average values and may vary in the field for individual trees. Stand examiners have the discretion to modify these values based on individual tree characteristics.

The following example illustrates a process to calculate retention.

The stand is mixed aspen and oak, prescribed for final harvest. The retention goal is 5% of the area, with retention of pine and oak targeted at a minimum 2/acre each where feasible.

Harvest area: 40 ac, 5% retention goal = 2 acres in retention (i.e.  $40 \text{ ac} \times 0.05 = 2$ )

Two, 10" oaks/acre (use N. hdwd column) =  $(2 \times 279 \times 40) \div 43,560 = 0.5 \text{ ac.}$

Two, 18", pines/acre (use Hemlock column) =  $(2 \times 346 \times 40) \div 43,560 = 0.6 \text{ ac.}$

Combined, scattered trees occupy 1.1 acres (0.5 + 0.6). To come up with remaining 0.9 acres of retention, use Table 3. below to estimate area of patches of various sizes. For example, the remaining 0.9 ac of retention could be more than satisfied by leaving a 1 ac patch, 236 ft in dia., or two ½ ac patches, 167 ft. in dia. each.

**Table 3. Common Patch Sizes**

Patch Size (ac.)	Patch dia (ft.)	Patch dia (ch.)
0.10	74	1.1
0.25	118	1.8
0.50	167	2.5
0.75	204	3.1
1.00	236	3.6

#### **B. Where the Retention Goal is a Percent of the Residual Basal Area.**

Typically, in stands managed for uneven aged objectives, retention goals are stated in terms of a percent of the residual basal area. For example, the retention goal in a northern hardwood stand prescribed for selection harvest may be 5% of the residual basal area left in trees with the characteristics described in the Retention Guidance section and repeated below:

- under-represented species
- conifer/deciduous diversity
- mast trees - at least 3 trees/acre > 10" dbh where feasible.
- large/super-canopy trees, at least 1 per 10 acres
- live cavity trees ( $\geq 3/\text{acre}$ ), live cavity tree plus snags (up to 10/acre) > 10" dbh where feasible)

A common northern hardwood prescription is to mark the stand to a residual BA of 80 sq. ft. Five percent of 80 would amount to 4 sq. ft. In the top part of Table 4. below, looking up 5% in the 80 BA row shows that 4 sq. ft. of the residual stand should be in retention trees (i.e., trees that provide habitat values as described in above list).

Using a 10 factor angle gauge, this amounts to 1 retention tree every 2 ½ plots ( $10 \div 4$ ), or 2 trees every 5 plots.

**Table 4. Basal Area Retention & Trees per Acre Retention for 80 BA Residual**

<b>Basal Area Retention Levels</b>				
<b>Residual BA</b>	<b>3%</b>	<b>5%</b>	<b>7%</b>	<b>10%</b>
<b>90</b>	3	5	6	9
<b>80</b>	2	4	6	8
<b>70</b>	2	4	5	7
<b>Trees Per Acre Retention for 80 BA Residual</b>				
<b>DBH</b>	<b>3%</b>	<b>5%</b>	<b>7%</b>	<b>10%</b>
<b>8</b>	7	11	16	23
<b>10</b>	4	7	10	15
<b>12</b>	3	5	7	10
<b>14</b>	2	4	5	7
<b>16</b>	2	3	4	6
<b>18</b>	1	2	3	5
<b>20</b>	1	2	3	4

Another way of expressing this is in trees/acre. For example, using the bottom part of Table 4., look down the 5% column to see how many trees per acre of various diameter classes would be needed to satisfy the retention goal. In a stand prescribed for an 80 sq. ft. residual with a 5% retention goal, this could be met with 5, 12" trees, or 2, 20" trees per acre. Usually retention goals will be accomplished using a combination of tree sizes.

## **7. COVER TYPE SPECIFIC CONSIDERATIONS**

### **A. NORTHERN HARDWOODS**

#### **1) Cover Type Characteristics:**

Northern hardwood forests are a widespread, climax community of mesic, generally well drained uplands. Composition varies, but is generally dominated by sugar maple with minor associates including basswood, beech, white ash, red maple, bigtooth aspen and yellow birch, among others. Historically, the cover type burned much less frequently than other upland cover types and consequently, its disturbance regime was dominated by single treefall gaps and occasional extensive areas of windthrow (Frelich and Lorimer 1991). Silviculture has resulted in homogeneous sugar maple dominance on well drained sites and red maple in more poorly drained sites, at the expense of a decline in confers (Zhang et. al. 2000). Prior to European settlement, the northern hardwoods cover type had a much larger white pine and hemlock component, with hemlock being especially prevalent in areas with finer textured soils and poorer drainage (Whitney 1986).

#### **2) Retention Considerations:**

*Under-Represented Species.* In northern hardwoods, under-represented species often include yellow birch, eastern hemlock, white pine, and black cherry. Efforts should be made to retain and encourage these under-represented species on a stand specific basis, especially larger individuals with high wildlife value and/or good form (the latter to serve as seed trees). Current Emerald Ash Borer and beech bark disease Guidance should be consulted to inform decisions on retaining ash and American beech, respectively. In selecting individual trees for

live tree retention, consider a mix of trees with longer lifespan and shorter lifespan. Sugar maple, yellow birch, hemlock, white pine, and northern red oak can live 200-300 years or more, whereas basswood, white ash, paper birch, and aspen rarely live more than 150 years. Retain and promote hemlock and white pine where they persist by maintaining and creating suitable sites for establishment through retention of nurse logs and exposure of mineral soil through prescribed surface fires or scarification. Where hemlock and pine local seed sources are absent, but where historical information and/or site conditions suggest these tree species were present, consider under-planting. Specific recommendations for conifer restoration are available for the Western Upper Peninsula (Herman et. al. 2004).

*Mast Producers.* The important hard mast producers in northern hardwood stands are American beech, and in more limited number of stands, northern red oak or hickory. Black cherry is the most important soft mast tree. Special effort should be made to retain oak and hickory where they occur because of the threat of beech bark disease to the beech hard mast resource.

*Structure.* Group selection thinning can be used to improve vertical and horizontal structural diversity, and may increase species diversity by encouraging growth of shade-intolerant and mid-tolerant species. Where snags and coarse woody debris are lacking, increase structural complexity by saving large diameter trees and allow them to die. Where intensive management for the purpose of increasing DWD is desired, girdling and felling of trees is an option. However, hemlock and white pine should not be girdled or felled, as they have greater retention values as live trees. If left, they will eventually become part of the dead wood pool. White pine is the best super-canopy tree candidate in northern hardwood stands, although hemlock, white spruce and red pine can also attain greater heights than many of the broad-leaved deciduous species in northern hardwood forests (Fowells 1965).

*Cavity Trees, Standing Dead, and Downed Wood.* Where possible, a variety of tree species should be retained as cavity trees, snags and down logs. Cavity density is nearly twice as great on beech trees as other common northern hardwood species (Kearney 2006). However, complete reliance on beech to provide cavities may be unwise because of mortality anticipated in the future due to beech bark disease, and because wildlife use may vary among tree species with different characteristics (e.g. “softwood” species such as white pine and basswood, vs. “hardwood” sugar maple and beech).

### **3) Wildlife**

Several plants and animals of concern occur in northern hardwood forests. Plants include walking fern (State threatened), hart’s-tongue fern (State endangered), goblin moonwort (State threatened), and fairy bells (State endangered); and animals include red-shouldered hawk (State threatened), northern goshawk (State special concern), and several neo-tropical migratory warblers. Refer to Michigan Natural Features Inventory (MNFI) Community Abstracts (see MNFI website) and the DNR Wildlife Action Plan (Eagle et. al. 2005) for more complete lists of species of concern.

#### **4) Rare Features/Communities:**

Limestone or dolomitic boulders found in the Niagran escarpment of eastern Lake Michigan and northern Lake Huron shorelines are unique geologic features found in northern hardwood stands in these areas. They serve as micro-habitat for several rare plant species including Hart's tongue fern, green spleenwort, and walking fern. Harvesting too close to the boulders can interrupt the canopy cover which may be required to maintain the micro-climate necessary for these plants. Where rare species have been identified, boulders should be protected in two ways: 1) protection from direct tree felling, and 2) protection from desiccation. To accomplish this, within 150 ft. of these boulders, retain all conifers and a total BA of at least 100 sq. ft. In addition, no cutting should be done within 100 feet of the boulders. No trees should be felled directly onto the boulders.

### **B. OAK**

#### **1) Cover Type Characteristics:**

Species composition in the oak cover type is predominantly red oak on more mesic sites, and some combination of black, white, red and/or northern pin oak on drier sites. The current broad distribution of mature oak dominated forests is the result of logging and fire history. The type occupies extensive areas that were once dominated by mixed white pine/red pine forests in which oaks were a subordinate species (Whitney 1987). The pines were harvested from these forests, and subsequent fires eliminated remaining pine and hardwood seed sources and favored oak sprouts as regeneration. Despite its current abundance, vigorous regeneration is poorly represented on all but the poorest sites, and oak will eventually succeed to oak-pine mixes on poor sites, pine-red maple mixtures on intermediate sites, and sugar maple dominated hardwoods on mesic sites.

#### **2) Retention Considerations:**

*Under-Represented Species:* In oak stands on poor to intermediate sites (outwash and ice contact topography, respectively), white pine, and to a lesser extent, red pine, are relatively common components, with white pine especially common in the understory. The pines grow more vigorously than the oaks on these sites and prior to the logging era, they were generally the dominant tree species. In addition to silvicultural techniques aimed at encouraging pine in harvested areas, the pines could be further encouraged by including large "seed tree" pines as retention, and protecting larger regeneration in retention patches. On intermediate sites, maintaining oak as a component in future stands may hinge upon decreasing the density of the strong competitor red maple. If encouraging oak regeneration is a goal, then red maple should not be favored for retention. On mesic sites, harvesting oak will nearly insure that it becomes less important in the future stand, as its seedlings are strongly out-competed by seedlings of other hardwood species (Abrams 1998). Because of this, and the broad range of ecological values oak provides, some red oak should be retained, in addition to other desirable under-represented species sometimes found on these sites (e.g. hemlock, yellow birch, white pine).

*Mast Producers.* Oaks are excellent hard mast producers and should be retained in the stand, if possible. Black, pin and white oak on poor sites are not long-lived, and many stands in Michigan are 90-100 years old, which is old for these species.

Where loss of vigor is evident or anticipated on dry sites, try to favor areas with oak regeneration for retention. Whether currently in the overstory or in the regeneration layer, favor oak species mixes on poor sites (e.g. black, red and white oak. This approach will increase the consistency of mast production among years, as different oak species can have large seed crops in different years. Amelanchier, cherry (black, pin, and choke), vaccinium and other soft mast producing species are also common on poor oak sites. On mesic oak sites, red oak and white oak can live >200 years. On these sites, red oak and beech are the most abundant high quality mast producers and beech is threatened by beech bark disease. For these reasons, oak should be favored for retention. Where a diversity of oak species exist in a particular stand or community, it is desirable to retain trees to promote the continuation of this diversity.

**Structure.** The oak cover type on poor to intermediate sites has a relatively open canopy that allows appreciable amounts of light to the forest floor. This, plus the relative abundance of intermediate shade tolerant species (e.g. amelanchier, white pine), can result in relatively complex vertical structure. Structural complexity can be enhanced by retaining white or red pine that is now in, or will reach, the super-canopy, and via partial harvesting to release understory shrubs and trees. White and red pines are the best super-canopy tree candidates on oak sites.

**Cavities.** On poor to intermediate oak sites, declining short lived oaks often have abundant cavities, as does aspen which is sometimes mixed with oak on the more mesic sites. However, the long-term persistence of these cavities cannot be relied upon. Preference could be given to white and red pine as cavity trees because they are likely to persist longer.

### **3) Wildlife**

Wildlife species of importance that are heavy users of mast in oak stands include white-tailed deer, black bear, wild turkeys, squirrels, ruffed grouse, jays, nuthatches and wood ducks (Martin et. al. 1951). Several plants and animals of concern may occur in oak forests or oak barrens. An example is the globally endangered Karner blue butterfly found in barrens communities. Other examples include silky aster, side-oats gamma grass, Great Plains spittlebug, and least shrew (all State threatened). Refer to MNFI Community Abstracts (see MNFI website) and the DNR Wildlife Action Plan (Eagle et. al. 2005) for more complete lists of species of concern.

### **4) Rare Features/Communities:**

**Savanna/Barrens Remnants.** Open canopy oak stands, particularly those of fire origin or those presently maintained by fire, have the potential to contain rare barrens or savanna species. Oak-pine barrens contain rare plants, invertebrates, songbirds, mammals, and reptiles. Prescribed fire is the most important management tool to maintain and enhance these remnant communities. If the community is degraded by excessive canopy closure, selective cutting of canopy trees may be necessary prior to periodic prescribed fires. This selective cutting/retention practice for maintaining and restoring barrens and savanna communities can be considered retention under the Guidance. In cases where fire is to be reintroduced, large trees should be favored for retention, as they are the most fire resistant.

## **C. PAPER BIRCH**

### **1) Cover Type Characteristics:**

Paper birch is not a common cover type in Michigan's upland temperate forests. It reached its peak abundance in the canopy in the mid 20<sup>th</sup> Century, in response to the widespread fires that followed the logging era. Since the late 1980s, drought, pests and pathogens, and old age have reduced the amount of birch. Before European settlement, it was probably even less abundant than it is now, and was primarily found in poorly drained depressions. In these sites, it regenerated on elevated micro sites on coarse wood and tip up mounds. At present, it is found in several natural communities and associations including rich conifer swamp (usually a cedar cover type), boreal forest (spruce-fir), aspen and northern hardwood forest.

### **2) Retention Considerations:**

Please see information on retention for the paper birch type in cedar, spruce-fir, and northern hardwood sections.

*Mast Producers.* There are few common hard mast species in this cover type. However, there may be several soft and hard mast shrubs and dwarf shrubs including *Corylus*, *Vaccinium*, *Rubus* and *Ribes*, that can benefit from harvesting disturbance in this type.

### **3) Species of Concern:**

Since paper birch is relatively rare as a pure cover type and is commonly associated with other dominant types, plant and animal species typically find their habitat requirements in the associated types such as rich conifer swamp (usually a cedar cover type), boreal forest (spruce-fir), aspen and northern hardwood forest. Several plants and animals of special concern occur in these communities including heart-leaved arnica (State endangered), purple clematis (State threatened), Canada rice-grass (State threatened), pine drops (State threatened), red-shouldered hawk, and northern goshawk. Refer to MNFI Community Abstracts and the DNR Wildlife Action Plan for more complete lists of species of concern.

## **D. ASPEN**

### **1) Cover Type Characteristics:**

Aspen is a common cover type and is found in all sites, except the extremes of acid peat soils and excessively drained outwash. Although the age class distribution on State lands in Michigan is skewed toward stands < 30 years old, there are some aspen stands older than the typical harvest age (i.e. > 50-70 years), where short-lived, early successional aspen is declining and stands are starting to succeed to other cover types. Common species in aspen understories vary as widely as aspen's distribution.

## 2) Retention Considerations:

*Under-Represented Species:* Aspen stands often are dominated by two aspen species; however, they may have species-rich tree and shrub understories that include: white pine, oaks, maples, beaked hazelnut, witch hazel, blueberry, honeysuckle and cherry. Aspen stands often provide good opportunities for maintaining and increasing tree and shrub diversity as one of the goals for retention, but there are few generalities given aspen's broad distribution. General recommendations are not very useful, except in red pine plantations, and assessment will have to be site specific. Decisions should be informed by habitat type, successional pathways, historic information, and species present. Given aspen's relatively short lifespan, retaining aspen trees and stand understory vegetation may result in the relatively rapid development of aspen snags, coarse wood, and a diverse understory.

*Mast Producers.* Oak and cherry are infrequently occurring mast-producing species that occur in aspen stands that should be retained.

*Structure.* Aspen stands are characterized by two major vertical structural strata, the canopy layer and a well developed understory. Opening up the understory via harvesting, and/or by overstory breakup due to mortality in older stands, will release advanced regeneration of other species and can stimulate aspen suckering. Leaving residual trees for singing/song/hunting perches can increase avian use of sawlog-size aspen stands. These layers, combined with retained, declining aspen trees and other longer lived species (maples, oaks, pines) will enhance vertical structure. As stands age, snag and coarse wood recruitment is often abundant, as a result of rapid self-thinning in aspen stands. The vast majority of the stems that die naturally are small and may have limited wildlife value. Furthermore, because aspen decays quickly, the lifespan of both snags and DWD is short. Retention consisting of both shorter-lived aspen with longer-lived species may provide a steady supply of cavities, snags, and coarse wood for several decades.

*Cavities.* Kearney (2006) found that older aspen and birch had cavity densities that were higher than any other species, but American beech. However, aspen's value as a cavity tree is diminished somewhat by its relatively short lifespan (<100yrs).

## 3) Wildlife

Important wildlife species that are dependant upon aspen are American woodcock, ruffed grouse and beaver. Several plants of special concern occur in these communities such as heart-leaved arnica, fairy bells, and rayless mountain ragwort. Animal species of concern include red-shouldered hawk, and northern goshawk. Refer to MNFI Community Abstracts (see MNFI website) and the DNR Wildlife Action Plan (Eagle et. al. 2005) for more complete lists of species of concern.

## E. HEMLOCK

### 1) Cover Type Characteristics:

Hemlock is a climax cover type and has the potential to be widespread on mesic, generally well drained to somewhat poorly drained uplands, and the finer textured soils of lake plains. It is also associated with ravines and the edges of swamps. Yellow birch, sugar maple and basswood are common associates. Historically, the cover type was most common on mesic and hydric upland sites that burned infrequently. The disturbance regime in hemlock stands was typified by gaps created from single tree fall and occasional larger windthrow disturbances (Frelich and Lorimer 1991).

### 2) Retention Considerations:

*Under-Represented Species:* Prior to European settlement, hemlock was much more widespread than it is currently (Whitney 1986). In areas where hemlock has declined, its common associate, yellow birch, has also declined sharply. In general, sugar maple has replaced hemlock on well drained sites, and red maple has replaced hemlock on more poorly drained sites (Zhang et. al. 2000). Because of hemlock's widespread decline and its high value for wildlife (see below), its presence as a cover type or as a minor associate in other types should be considered a notable ecological attribute. High priority should be given to preserve the hemlock that is left. Where hemlock and yellow birch occur as components of northern hardwood or lowland cover types, they should be favored for retention. Areas with hemlock seedlings and saplings should also be favored for retention.

*Mast Producers.* Few high quality mast producers are common in hemlock stands (e.g. beech), and where they occur, their retention may be of lower priority than retaining hemlock and its associate, yellow birch.

*Structure.* The structure of hemlock dominated stands may be relatively simple or complex, depending on stand history. Even-aged patches of hemlock, which are not uncommon in the upper Great Lakes region (Tyrell and Crow 1994), have relatively simple structure because their deep, and intermingled canopies allow less light to reach the forest floor than is needed to support understory vegetation. In mixed species stands, deep hemlock canopies add to the structural complexity. In old age stands, gap dynamics, hemlock's very high shade tolerance, and the slow decay rate of its dead wood, contribute to vertical structural complexity of live trees and to standing and down dead wood (Marx 2005, Tyrell and Crow 2004).

Remnant, never harvested, hemlock-dominated stands exist, but are uncommon outside of Sylvania Wilderness Area, Porcupine Mountains State Park and the Huron Mountain Club. Stand examiners should assess hemlock-dominated stands, or portions of stands, for old age characteristics such as trees in many size classes, some very large trees, and large amounts of coarse woody debris and snags. Areas with these old age characteristics could be considered for reserve area status.

*Cavities.* Old hemlock and yellow birch attain large diameters and often have numerous cavities. Given their long lifespan, individuals of both species may provide cavities for a long period of time.

### 3) Wildlife

Several plants and animals of concern occur in hemlock forests including walking fern (State threatened), hart's-tongue fern (State endangered), goblin moonwort (State threatened), fairy bells (State endangered), red-shouldered hawk (State threatened), and northern goshawk (State special concern). Refer to MNFI Community Abstracts (see MNFI website) and the DNR Wildlife Action Plan (Eagle et. al. 2005) for more complete lists of species of concern.

Many important wildlife species exhibit a preference for habitat found in hemlock forests, or in landscapes with a component of hemlock. Hemlock forest habitat contributes to maintaining viable populations of native wildlife. Birds associated with hemlock in Wisconsin include the Black-throated Green Warbler, Blackburnian Warbler, Winter Wren, Red-breasted Nuthatch, Solitary Vireo, Brown Creeper, Hermit Thrush, Northern Parula, and Yellow-rumped Warbler. Hemlock provides winter cover for white-tailed deer, ruffed grouse, and turkey. Mammals such as red squirrel and American marten, as well as a number of amphibians and reptiles, are associated with hemlock forests. In areas where lowland conifer stands are uncommon, upland hemlock stands may provide winter thermal cover for deer, moose, and other terrestrial species.

In addition, many bird species that depend on conifers, whether as the dominant cover type or as a minor component in hardwood stands, may have declined along with the representation of hemlock and other conifers that has occurred since the logging era (Drapeau et. al. 2000). Considering the benefits to wildlife from the hemlock cover type, enhancing hemlock in stands where it occurs, or could occur, should be a high priority.

## F. WHITE PINE

### 1) Cover Type Characteristics:

Although it is a minor cover type in terms of acreage, the white pine cover type has had the fastest rate of acreage expansion of any State Forest cover type over the past twenty years, and it is a minor component in many cover types and across a broad range of habitat types (Burger and Kotar 2003). White pine may be more broadly distributed than any other species across gradients of fertility and hydrology; it is only excluded from the wettest sites. Where seed sources exist, it is now common in the understory of aspen and oak cover types, many of these stands that were dominated by mixed red and white pine prior to the logging era.

### 2) Retention Considerations:

*Under-Represented Species.* White pine occupies a wide range of sites, but expresses dominance most commonly on wet hummocky areas and well drained upland sites. These areas are characterized by relatively diverse tree communities with associates including oak, red pine (upland only), aspen, hemlock, and red maple, and, in lowland areas, other conifer species. Given this high potential diversity and the large variability among stands, evaluation of under-represented species needs to be site specific. White pine's value as a retention tree comes from its long lifespan (up to 500 years), potential super-canopy height growth, long life as a snag or as DWD and other wildlife values (see below).

Because of these characteristics, retention of white pine in all size classes should have high priority.

*Structure.* Except for dense, self thinning stands, white pine forests can have high vertical structural complexity because the canopies allow much light to reach lower strata. In the older stands, white pines can be present in all height classes including super-canopy trees, and several subordinate tree species can be present, including oaks and maples.

*Mast Producers.* In some parts of the State, the white pine cover type can have a large, multi-species oak component. Wherever opportunities exist, managers should enhance and perpetuate the oak component in white pine stands. These sites may be important mast producing areas for wildlife such as white-tailed deer and black bears. In other parts of the State, white pine has a large component of northern hardwoods. In these stands, the hard mast producing species including beech, black cherry, basswood, and ironwood should be retained.

*Cavities.* Large white pine, or other long-lived species in white pine stands, could provide a long-term cavity resource (see specifics below). These trees can be supplemented by shorter-lived species, such as aspen, that may develop cavities at a younger age.

### **3) Wildlife**

Important wildlife species that use white pine stands include black bear, fisher, and pine marten. Several plants and animals of special concern occur in white pine dominated communities including heart-leaved arnica (State endangered), purple clematis (State threatened), Canada rice-grass (State threatened), pine drops (State threatened), bald eagle (State threatened), and merlin (State threatened). Refer to MNFI Community Abstracts and the DNR Wildlife Action Plan for more complete lists of species of concern.

Specific features of white pine with value for wildlife include:

- a) Large, mature trees with broken tops provide habitat for cavity nesting wildlife.
- b) Black bears will make dens under the root mass of uprooted trees. Uprooted trees should be retained in these stands. These structures can be promoted by leaving trees to blow over after harvest or retaining trees in a salvage cut.
- c) Bark foraging bird species such as the brown creeper, pine warbler, white-breasted nuthatch, and red-breasted nuthatch search for insect prey in white pine's deep bark crenulations.
- d) Black bear sows commonly leave their cubs at mature white pine trees while foraging nearby in non-pine forest communities. These trees have thick, fissured bark that escaping cubs can easily climb. Super-canopy trees that are at least 20 inches DBH are preferred. Trees that have bite marks, claw marks and show signs of disturbance at the base are trees that sows may be using year after year (Rogers and Lindquist, 1992).
- e) Given its slow decomposition rates and large size, white pine has long residence time as a snag and as DWD.
- f) Trees infested with heart rot can be easily excavated by large woodpeckers.

## G. RED PINE

### 1) Cover Type Characteristics:

In Michigan, red pine is a dominant or associate tree species in several natural communities. High quality natural communities containing red pine, including dry-mesic and dry northern forest, are among the rarest natural communities in the State. Before the logging era, mixed pine forests with red and white pine were a common cover type in areas now dominated by oaks, and red pine were found more frequently in forests and barrens now dominated by jack pine (Whitney 1986). In contrast to natural communities, there are over 950,000 acres of red pine plantations in Michigan. These plantations are distributed broadly, occurring on dry and dry-mesic sites where it occurred naturally, and on mesic sites. Many of the plantations are at, or nearing maturity, and provide the opportunity for leaving large residual red pine that could be used for several different retention goals (see below).

### 2) Retention Considerations:

*Under-Represented Species:* In the red pine cover type, red pine and white pine, a common associate, are good candidates for retention because of their longevity. Priorities for retention can be set by viewing mixed pine communities as being under-represented in the landscape and across State forests, instead of as a particular species. At final harvest, even-aged red pine plantations provide excellent opportunities for conversion to under-represented, multi-cohort red pine or mixed pine-oak communities on appropriate habitat types (see Burger and Kotar 2003). Careful planning for red pine retention on candidate sites and the possible re-introduction of fire would be critical elements of a restoration plan for these communities. Although red pine was not common on mesic sites, retention of some red pine at final harvest in plantation stands might provide some of the same values (e.g. super-canopy trees) as white pine or hemlock in the future hardwood stand. In general, live wood/legacy tree retention objectives can be met by leaving mature red pine as individual trees, clumps, or simulated fuel breaks. Determination of the appropriate live tree retention location should consider impacts on harvesting, regeneration, recreation and visual management.

*Mast Producers.* The red pine cover type can often have a large, multi-species oak component. These stands may be extremely important mast producing areas for wildlife such as white-tailed deer and black bears. Managers should enhance and perpetuate the oak component when present.

*Structure.* Except in dense, self-thinning stands, red pine stands can have high vertical structural complexity because the canopies allow much light to reach lower strata. In the older stands, red pine stands can include several subordinate tree species including oaks and red maple.

*Cavities.* Large diameter red pine, or other long-lived species in red pine stands (e.g. white pine), may provide a good long-term cavity resource (see specifics below). These trees can be supplemented by shorter-lived species, such as oaks and jack pine, that may develop cavities at a younger total age than pine and other long-lived species.

### 3) Wildlife

Important wildlife species that use red pine stands include pine warblers, fisher and pine marten. Several plants and animals of special concern, in addition to the barrens plant species described below, occur in red pine forests. Refer to MNFI Community Abstracts (see MNFI website) and the DNR Wildlife Action Plan (Eagle et. al. 2005) for more complete lists of species of concern.

### 4) Rare Features/Communities:

As described above, high quality natural communities containing red pine, including dry-mesic and dry northern forest, are among the rarest natural communities in the State. Historically, these communities were maintained by frequent surface fires and infrequent crown fires. These communities should be identified and considered for active maintenance/restoration of community integrity.

*Barrens/Prairie Remnants.* Red pine stands, particularly those of fire origin, have the potential to contain barrens and prairie remnants. Prior to management, care should be taken to assess the potential for maintaining and enhancing barrens and prairie remnants. Diagnostic species abundant in high quality barrens and prairie remnants include big and little bluestem, pale agoseris, rough fescue, Hill's thistle, Canada rice grass, and Alleghany plum. In addition to fire, plant species associated with barrens/prairie remnants can be enhanced with silvicultural practices that disturb the forest floor and expose mineral soil. Areas that are currently high quality barrens and prairie remnants, or have the potential to be, should receive consideration for maintenance or restoration management practices that include careful consideration of retention characteristics and the reintroduction of a frequent fire regime.

## H. JACK PINE

### 1) Cover Type Characteristics:

In Michigan, jack pine is a dominant or associate tree species in several natural communities. It is dominant in dry forests on the excessively well drained sands of outwash plains topography. These communities are the most fire prone in the State. Areas with jack pine are often mono-dominant, but common associates may include red pine, white pine, northern pin oak, and bigtooth aspen. Oak is an associate in areas with good cold air drainage, as it is susceptible to, and excluded from, areas with late season frosts.

### 2) Retention Considerations:

*Under-Represented Species:* Red and white pine are good candidates for retention because of their longevity, positive impacts on vertical structure, cavities and wildlife values (see below and elsewhere). Retaining old, large diameter jack pine is also important because older jack pine is generally under-represented in the jack pine cover type. In addition, they generally have much shorter lifespan than red pine, thus will produce snags more quickly, with snags typically persisting < 20 years following mortality. Leaving some wildfire burned areas unsalvaged will increase the representation of snags and DWD on the landscape. Consideration of forest health risks must be made when areas of fire killed pine

are left untreated, due to the potential to create brood locations for various pine beetles that could endanger nearby healthy, unburned stands. For example, jack pine more than 50 years of age is highly susceptible to jack pine budworm infestations.

***Mast Producers.*** Oaks are the only mast producers in jack pine stands. If the oak trees are healthy and vigorous, leave them as mast trees, favoring species mixtures where they exist. In some areas, northern pin oak or black oak may be the only mast tree options.

***Structure.*** Jack pine stands have relatively simple vertical structure, as jack pine has a relatively short stature and shallow crown, and understories are often sparse. Retaining or promoting larger diameter and taller red pine, white pine and oak will increase vertical structure. Much of the jack pine area is clearcut harvested with a rotation of 50-60 years. Although this matches the average pre-settlement fire rotation, because fire was more of a chance event, and because fire susceptibility varied over the landscape, there were many areas without fire for much longer than 60 years, and there were areas that burned much more frequently than every 60 years (D. Cleland, unpublished data). The areas that burned less frequently would have had greater densities of snags and DWD from short-lived jack pine, oaks, and aspen, and large longer-lived red pine and white pine trees. Areas that burned very frequently might have developed barrens characteristics (see below). Landscape (i.e. horizontal) structural complexity could be enhanced by more closely emulating the variation in disturbance frequency that typified these areas and not just the average fire rotation. Furthermore, unlike clearcut areas, burned areas typically have undulating boundaries with peninsulas of unburned areas with live trees that jut into burned areas, as well as islands of live trees in the middle of burned areas (OMNR 2001). To more closely emulate natural disturbance, a pattern of island and peninsula shaped residual patches is advised. The general approach is as follows: a) retain islands of greater than 0.5 acre, and peninsular areas; b) island patches will be left as permanent retention. Peninsulas can be harvested when adjacent stands are harvested, if feasible; c) if harvesting of peninsulas is not feasible in future harvests, then peninsulas can be partially cut at the time of the original harvest, removing as much as 50% of the trees by group selection.

***Cavities.*** Large red or white pine, if present, would provide the best long-term cavity resource (see specifics below). These trees can be supplemented by shorter-lived jack pine, aspen and oaks that may develop cavities at a younger total age than pine and other long-lived species.

### **3) Wildlife:**

Approximately 90,000 acres of jack pine on State Forest land is designated as essential habitat for Kirtland's warbler (KW) management. For those stands in designated KW Management Areas, managers should refer to the Kirtland's Warbler Habitat Management Guidance.

As a general rule, jack pine stands managed for KWs should be at least 200 acres in size, but preferably 500 acres or greater. An ideal stand would contain a mosaic of highly stocked jack pine (1,600 trees/acre), over 75% of the area with the remaining 25% left unstocked. Historically, this mosaic has been achieved through planting in an opposing wave pattern. Large KW treatments serve an

important role for open and shrubland species during early stages of regeneration. These species include the eastern bluebird (if snags are present), white-tailed deer, wild turkey, American woodcock, upland sandpiper, and common nighthawk. Several plants and animals of special concern in addition to KW and the barrens plant species described below occur in jack pine forests. Some species are dependent on snags in jack pine stands; these include northern myotis, eastern bluebird, northern saw-whet owl, and black-backed woodpecker. Refer to MNFI Community Abstracts and the DNR Wildlife Action Plan for complete lists of species of concern.

#### **4) Rare Features/Communities:**

Jack pine stands, particularly those of fire origin, have the potential to contain barrens and prairie remnants. Prior to management, care should be taken to assess the potential for maintaining and enhancing barrens and prairie remnants. Diagnostic species abundant in high quality barrens and prairie remnants include big and little bluestem, pale agoseris, rough fescue, Hill's thistle, Canada rice grass, and Alleghany plum. In addition to fire, plant species associated with barrens/prairie remnants can be enhanced with silvicultural practices that disturb the forest floor and expose mineral soil. Areas that are currently high quality barrens and prairie remnants, or have the potential to be, should receive consideration for maintenance or restoration management practices that include the careful consideration of retention characteristics and the reintroduction of a frequent fire regime.

### **I. SPRUCE-FIR**

#### **1) Cover Type Characteristics:**

The spruce-fir cover type is usually associated with boreal and sub-boreal forest communities, but can also be found in the dry-mesic and mesic sites in northern temperate regions. The cover type is later successional, often replacing jack pine, aspen and birch, as both white spruce and balsam fir are fire intolerant and more shade tolerant than the species they replace. Spruce-fir is not a common cover type in Michigan, but it may increase in this era of fire suppression especially on the more poorly drained pine sites.

#### **2) Retention Considerations:**

*Under-Represented Species:* Spruce are often less abundant than fir in the spruce-fir type. This is likely because the type is often late successional, with spruce regeneration disadvantaged by its lesser shade tolerance (Kneeshaw et. al. (2006) and more specific seedling establishment substrate requirements (Simard et. al. 2003). Thus, if the management goal is to increase spruce representation, then spruce could be considered under-represented. Spruce has greater maximum lifespan (300+ years) than fir (<150 years) (Newbery, et. al. 200X). In addition, balsam fir greater than 60 years of age is highly susceptible to spruce budworm infestations. For these reasons, windfirm (e.g. super-canopy) spruce should generally be favored over balsam fir for retention. However, high retention (>20 %) or conversion to uneven-aged management should be considered in this forest type because neither species is very windfirm, thus isolated retention patches blow over easily.

*Mast Producers.* There are few common hard mast species in this cover type. However, there may be several soft and hard mast shrubs and dwarf shrubs including *Corylus*, *Vaccinium*, *Rubus* and *Ribes*, that can benefit from partial harvesting.

*Structure.* Maintaining both spruce and fir components is important in these stands. Spruce have larger diameter and are taller than fir, resulting in forests that have a two-tiered structure or a multi-storied structure in old age stands (Newbery et. al. 2006). On wetter, or fire protected sites (e.g. leeward sides of bodies of water and islands), spruce-fir forests can persist long enough between large scale disturbances, that individual to multiple tree-fall gaps predominate (Newbery et. al. 2006). Extremely shade tolerant northern white cedar or hemlock can become components in these late stage forests, and paper birch can establish in some gaps on rotting logs (Frelich 2002). On drier sites, these forests may have more even-aged structure. These patterns can be emulated with harvest systems that match local conditions. Both fir and spruce have persistent snags that can stand 35+ years after mortality, and both have decay resistant DWD that can persist for 60+ years (Newbery et. al. 2004).

*Cavities.* In spruce-fir stands, spruce may be preferred for retention as cavity trees because of its larger size and greater longevity.

### **3) Wildlife:**

Important wildlife species that use spruce-fir include moose, black bear, fisher, and bobcat. Where the spruce-fir type is within the influence zone of the Great Lakes, a variety of orchids are species of concern, as well as one raptor, the merlin. Referring to management guidance for these species may be critical to maintaining their presence. Other plants of special concern include squashberry, northern fairy bells, and small-flowered woodrush. Refer to MNFI Community Abstracts and the DNR Wildlife Action Plan for more complete lists of species of concern.

### **4) Rare Features/Communities:**

Spruce-fir communities with late successional characteristics are relatively rare. Stand examiners should consider identifying spruce-fir communities with old age characteristics (some large trees, treefall gaps, and abundant snags and downed wood as potential reserve areas).

## **J. LOWLAND CONIFERS**

### **1) Cover Type Characteristics:**

The Lowland Conifer cover type includes a broad array of mixed conifer dominated forested wetland communities. Natural communities include poor conifer swamps, rich conifer swamps, relict conifer swamps, and hardwood-conifer swamps. Dominant tree species include balsam fir, cedar, tamarack, black and white spruce, and jack pine. Sites may also include, to a lesser extent, aspen, birch, cottonwood, balsam poplar, black and red ash, red and silver maple, elm, and swamp white oak.

## **2) Retention Considerations:**

*Forest Treatments in Lowlands.* Treatments have been conducted in lowland conifer forested systems with varying success. Cuttings in these systems were common on State lands in the 1970s and 1980s, as part of a concerted effort to improve white-tailed deer range. Treatments did improve winter survivorship of deer and many sites produced successful regeneration. On many sites, however, multiple factors hindered regeneration, including: 1) alteration of evapo-transpiration potential causing surface water level to increase, and 2) excessive persistent deer browsing.

Because of the fragility of hydric soils, harvest treatments should be conducted in winter, with frozen ground conditions, as much as possible. Harvesting in these sensitive sites should be done using low ground pressure equipment with close attention given to the potential for rutting, soil compaction, root damage and disruption of sub-surface drainage. In areas with high winter deer densities, high levels of residual slash and tops may be necessary to limit deer access to regeneration to prevent over-browsing.

*Under-Represented Species.* Similar to many upland sites, treatments should attempt to protect under-represented conifer species particularly cedar, hemlock, and white pine. In systems where black ash occurs, current Emerald Ash Borer Guidance should be consulted to inform decision on retaining ash.

*Mast Producers.* Mast producing tree species are uncommon in lowland forest sites. However, canopy gaps can be important for mast producing shrubs, grasses and forbs. These plants, including skunk cabbage, are important sources of spring forage for black bears.

*Structure.* Often trees in lowland forested communities are subject to windthrow during severe storms, as they have shallow roots. This disturbance, along with lightning strikes, has the potential to create a structurally and compositionally complex forest of many age classes and tree species. In stands lacking these characteristics, vertical structure can be enhanced by retaining or promoting a broad array of species and size/age classes.

*Cavities.* Lowland forested communities with high levels of short-lived species like aspen and birch may have adequate levels of snags and coarse woody debris present. However, long-lived species within these systems may have not yet reached the age where cavities have developed. To accelerate this process, girdling and felling of some trees is an option. Cedar and tamarack downed wood may persist for long periods of time due to its decay resistance.

## **3) Wildlife:**

At least 16 rare plants and 15 rare animal species are associated with these communities, including the following species of special concern: Ram's Head Orchid; Tamarack Tree Cricket; Eastern Massasauga; Blanding's turtle; Spruce Grouse; and Black-backed Woodpecker. One State-listed endangered species (Hine's Emerald Dragonfly) and six State-listed threatened species (Calypso Orchid; Limestone Oak Fern; Black Crowberry; Spotted Turtle; Long-eared Owl; and Red-shouldered Hawk) are associated with lowland conifer forests.

With the onset of winter, lowland conifer is a preferred habitat for resident wildlife species. During the winter months, snowshoe hare, bobcat, gray wolf, and white-tailed deer all intensify their use of lowland conifer forests, particularly northern white cedar. Northern white cedar is a preferred species in deeryards because it provides excellent protection from snow and wind, and is the only browse species that, by itself, will maintain deer over winter in good health. Dense, mature lowland conifer stands exhibit narrow thermal ranges, warmer average temperatures, low windflow, and diminished hazardous conditions. High quality deer wintering areas are characterized by having approximately 50% of the landscape in productive, mature or over-mature, well-stocked (100 square feet of basal area) coniferous stands. Shelter requirements for deer may vary considerably dependent on the magnitude of winter weather severity and the quality and quantity of food available.

## **K. LOWLAND HARDWOODS**

### **1) Cover Type Characteristics:**

The Lowland Hardwood cover type includes a broad array of deciduous dominated forested wetland communities. Natural communities include hardwood-conifer swamp, northern swamp, southern swamp, and southern floodplain forest. Dominant tree species include aspen, birch, cottonwood, balsam poplar, black and red ash, red and silver maple, elm, and swamp white oak. Sites may also include, to a lesser extent, northern white cedar, tamarack, balsam fir, and black and white spruce. These conifer species may have been more dominant on many these sites historically. Lowland hardwoods are generally either swamps or floodplains that may be flooded in the spring and/or fall, often causing the ground layer to be relatively sparse. However, on some sites, tree density can be low which can result in a dense groundcover.

### **2) Retention Considerations:**

*Forest Treatments in Lowlands.* Treatments have been conducted in lowland hardwood forested systems with varying success. Cuttings in these systems were common on State Forest lands in the 1970s and 1980s, as part of a concerted effort to improve white-tailed deer range. Treatments did improve winter survivorship of deer and many sites produced successful regeneration. However, on other sites, multiple factors hindered regeneration, including: 1) alteration of evapo-transpiration potential causing surface water level to increase, and 2) excessive persistent deer browsing.

Because of the fragility of hydric soils, harvest treatments should be conducted in winter, with frozen ground conditions, as much as possible. Harvesting in these sensitive sites should be done using low ground pressure equipment with close attention given to the potential for rutting, soil compaction, root damage and disruption of sub-surface drainage. In areas with high winter deer densities, high levels of residual slash and tops may be necessary to limit deer access to regeneration to prevent over-browsing.

*Under-Represented Species.* Many lowland hardwood systems were formerly dominated by conifer species. Similar to many upland sites, harvest treatments should attempt to protect under-represented conifer species particularly cedar,

hemlock, and white pine. Where black ash occurs, current Emerald Ash Borer Guidance should be consulted to inform decision on retaining ash.

*Mast Producers.* Mast producing tree species are uncommon in lowland forest sites. However, canopy gaps can be important for mast producing shrubs, grasses and forbs. These plants, including skunk cabbage, are important sources of spring forage for black bears

*Structure.* Often trees in lowland hardwood communities are subject to windthrow, as they have shallow roots. This disturbance, along with lightning strikes, has the potential to create a structurally and compositionally complex forest of many age classes and tree species. In stands lacking characteristics, vertical structure can be enhanced by retaining or promoting a broad array of species and size/age classes.

*Cavities.* Lowland forested communities with high levels of short-lived species like aspen and birch may have adequate levels of snags and coarse woody debris present. However, long-lived species within these systems may have not yet reached the age where cavities have developed. To accelerate this process, girdling and felling of some trees is an option. Cedar and tamarack downed wood may persist for long periods of time due to its decay resistance.

### **3) Wildlife:**

Endangered, threatened or special concern species include: eastern fox snake, eastern massasauga, smallmouth salamander, spotted turtle, Blanchard's cricket frog, wood turtle, eastern box turtle, Northern Goshawk, Red-shouldered Hawk, Bald Eagle, Merlin, Cerulean Warbler, Hooded Warbler, prothonotary warbler, yellow-throated warbler, gray wolf, moose, Indiana bat, eastern pipistrelle, and woodland vole. Refer to MNFI Community Abstracts and DNR Wildlife Action Plan for more complete lists of special concern species.

## **L. NORTHERN WHITE CEDAR**

### **1) Cover Type Characteristics:**

Northern white cedar is a dominant or associate tree species in several natural communities. In the rich conifer swamps that it dominates, common associates are black and white spruce, balsam fir, white pine, hemlock, paper birch, red maple, and tamarack, and alder and hazelnut shrubs. White cedar can also dominate upland sites, most notably those with thin soil overlying dolomitic bedrock, such as along the Niagra escarpment. Cedar swamps are climax communities that can maintain themselves for hundreds of years, in the absence of any large scale disturbances, excessive herbivory, or alteration of hydrology. Due to past logging, most cedar swamps are even-aged and relatively young (about half the cedar stands on State Forest lands are <100 years old) with poor representation of seedling and sapling size/age classes (Heitzman et. al. 1997). This may be due to a number of factors including stand development stage, deer herbivory and/or lack of suitable regeneration substrates.

## 2) Retention Considerations:

*Under-Represented Species.* Cedar swamps contain a broad but variable mix of species. As such, decisions about retention aimed at increasing under-represented species should be made on a site-by-site basis. Where black ash occurs, current Emerald Ash Borer Guidance should be consulted to inform decisions on retaining ash.

*Mast Producers.* Mast producing tree species are uncommon in cedar swamps. However, opportunities may exist to maintain or increase representation of soft mass shrub species.

*Structure.* Given the high shade tolerance of cedar, its long potential lifespan (informally reported at 600 + years, Lee Frelich, personal communication), the diverse structures and shade tolerances of its associated species, the vertical structure of cedar swamps can be complex. Vertical structure can be enhanced by retaining or promoting a broad array of species and size/age.

*Cavity Trees, Standing Dead, and Downed Wood.* Old cedar trees often have cavities and due to its longevity and decay resistance, cavities may have long life spans. Given the current age structure of cedar stands, large snags and coarse woody debris may be at low density. To accelerate the development of DWD, girdling and felling of some trees is an option. Downed cedar may persist for long periods of time due to its decay resistance. When sufficiently decayed, cedar can be an important seedling establishment substrate (Marx 2005).

## 3) Wildlife:

Several plants and animals of concern occur in cedar dominated vegetative communities, with a greater number of rare plants occurring in cedar swamps than in any other habitat (Epstein et. al. 2002). Examples of rare plants include the calypso orchid (State threatened), limestone oak fern (State threatened), ram's head orchid (State special concern), black crowberry (State threatened). Examples of rare animals include the red-shouldered hawk (State threatened), eastern massasauga (State special concern), and Hine's emerald dragonfly (State endangered). Refer to MNFI Community Abstracts and the DNR Wildlife Action Plan for more complete lists of species of concern.

Cedar swamps provide habitat for many wildlife species, including critical winter habitat for deer, snowshoe hare, bobcat, black bear and gray wolf. Northern white cedar is a preferred species in deeryards because it provides excellent protection from snow and wind, and is the only browse species that, by itself, will maintain deer over winter in good health. Dense, mature stands exhibit narrow thermal ranges, warm average temperatures, low wind flow, and diminished hazardous conditions. High quality deer wintering areas are characterized by having approximately 50% of the landscape in productive, mature or over-mature, well-stocked (~100 square feet of basal area with a minimum 70% canopy closure) coniferous stands. Shelter requirements for deer may vary considerably dependent on the magnitude of winter weather severity and the quality and quantity of food available. In order to perpetuate this valuable wildlife habitat, it may be necessary to identify areas that can be actively managed and regenerated without conversion to another type.

#### **4) Rare Features/Communities:**

Several rare communities contain cedar as a dominant or component species. For communities identified by the Wisconsin Natural Heritage Inventory, these include: Alvar, bedrock shore, clay seepage bluffs, and upland mesic cedar forests (Epstein et. al. 2002). The association of these communities with those identified by Michigan Natural Feature Inventory (Michigan State University Extension, 2006) is not established.

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